

## VARIATION IN BITTERBRUSH (*PURSHIA TRIDENTATA* PURSH) CRUDE PROTEIN IN SOUTHWESTERN MONTANA

Carl L. Wambolt<sup>1</sup>, W. Wyatt Fraas<sup>1</sup>, and Michael R. Frisina<sup>2</sup>

**ABSTRACT.**—The objective of this study was to determine if crude protein varies significantly during late summer and midwinter among stands of bitterbrush (*Purshia tridentata* Pursh) in southwestern Montana. A secondary objective was to determine if leaves, when present, contribute significant additional protein in the region. Nine sites with different environmental conditions and within a radius of 14.5 km were studied. Bitterbrush leaves and leaders collected in August 1990 and 1991 and February 1991 were used for crude protein and leaf-to-leader ratio determinations. Crude protein differed ( $P < 0.001$ ) among sites for both leaves and leaders on individual collection dates. Crude protein in leaves was nearly twice the level found in leaders. Because few leaves were present in February, they increased crude protein in total foliage by only 0.3% over twigs alone. February crude protein levels averaged 6.8% for total foliage, which is below the estimated requirement for wintering deer.

*Key words:* *Purshia tridentata*, bitterbrush, crude protein, winter range, big game nutrition, Montana.

Protein is one of the most important nutrients for wintering ungulates (Dietz 1972). Welch et al. (1983) estimated that winter crude protein levels of *Purshia tridentata* Pursh (bitterbrush) are not high enough to meet ungulate requirements, but postulated that protein content might vary with populations of bitterbrush. Differences in bitterbrush protein content between sites have been noted (Gimta et al. 1978), although not between local habitat types (Morton 1976). Slausen and Ward (1986) found no difference in crude protein among 3 Colorado accessions in a common garden, but Welch et al. (1983) found differences in a common garden test with plants from a wider geographical area. No differences in nutrient content have been found at varying browse levels of bitterbrush plants (Dietz et al. 1962, Shepherd 1971). Crude protein levels were higher when winter leaves were present (Dietz et al. 1962), but winter leaf presence varies between populations of bitterbrush (Welch et al. 1983).

Our objective was to determine if crude protein varies significantly during late summer and midwinter among stands of bitterbrush in southwestern Montana. Secondarily, we wished to determine if bitterbrush leaves in our region contribute significant additional crude protein quantities when present.

### METHODS

#### Study Sites

Nine study sites were chosen primarily to represent bitterbrush stands from a range of environmental conditions (Table 1). This included burned sites and bitterbrush sites protected from browsing. All study sites were located within a radius of 14.5 km near Butte and Anaconda in southwestern Montana. Long-term climatic records were available for the general study area from the Anaconda weather station at 1700 m elevation. Annual precipitation at Anaconda averages 340 mm, with 47% received between April and July (NOAA 1991).

Vegetation types at all but 3 sites (burn, unburn, and High Rye) were seral stages of the bitterbrush–bluebunch wheatgrass (*Agropyron spicatum* Pursh) habitat type (Mueggler and Stewart 1980). The dominant shrub was bitterbrush, but understory vegetation was regressed (Fraas et al. 1992) on the other 6 sites from the described potential climax composition (Youtie et al. 1988).

The Butte site at Maude S Canyon, near Butte, Montana, was selected because it receives no ungulate browsing. The plant community consisted of bitterbrush, *Centaurea maculosa* Lam. (spotted knapweed), *Ribes cereum* Dougl. (squaw currant), and *Rosa woodsii* Lindl. (Woods rose).

<sup>1</sup>Department of Animal and Range Sciences, Montana State University, Bozeman, MT 59717.

<sup>2</sup>Montana Fish, Wildlife, and Parks, Butte, MT 59701.

TABLE 1. Topographic characteristics of the 9 study sites. Data from the last 4 sites were obtained from Guenther (1989).

Site	Elevation (m)	Slope (%)	Aspect (degrees)
Butte	1730	26	234
Cattle enclosure	1830	16	188
Cattle + deer	1820	10	190
Burn	2010	21	220
Unburn	2010	24	180
Powerline	1640	16	85
Willow Creek	1780	31	110
Railroad Gulch	1650	32	115
High Rye	1940	35	120

At Dry Cottonwood Creek in the Deerlodge district of the Deerlodge National Forest, a livestock enclosure with deer-only use was studied and known as the cattle enclosure site. Near the enclosure, a bitterbrush stand was studied and known as the cattle + deer site because it sustained both cattle and mule deer browsing. These 2 sites have a scattered overstory of *Pseudotsuga menziesii* [Mirb.] Franco (Douglas-fir). A high number of native perennial forbs occurred in the understory on these sites.

Two sites were selected to gauge the impacts of burning bitterbrush in southwestern Montana. The 2 sites (burn, unburn) were situated on either side of the burn line on the south flank of Steep Mountain, 8 km northwest of Butte, in the Butte District of the Deerlodge National Forest. The plant community on these 2 sites was a bitterbrush–mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* [Rydb.] Beetle)–bluebunch wheatgrass association intermediate to the big sagebrush–bluebunch wheatgrass and bitterbrush–bluebunch wheatgrass habitat types of Mueggler and Stewart (1980). The prescribed burn was conducted 3 November 1981 after a year's rest from livestock grazing to increase fuel loads. Livestock use resumed 15 September 1982. When sampled for protein content, bitterbrush on the burned site was significantly lower in canopy cover ( $P > 0.01$ ), flower production ( $P > 0.1$ ), and seed production ( $P > 0.1$ ) than on the unburned site (Fraas et al. 1992).

Four sites were located on the Mount Hugin Wildlife Management Area (MHWMA), owned and managed by Montana Fish, Wildlife, and Parks. The Powerline site was on a slope 50 m above a perennial stream on the north-

east edge of the MHWMA big game winter range. The plant community consisted of bitterbrush and spotted knapweed. The Willow Creek site was near the top of a grassy ridge 150 m above Willow Creek. This site supported a relatively large amount of *Elymus cinereus* Scribn. & Merr. (basin wild rye), along with other perennial grasses and bitterbrush. This area was used as winter range by mule deer, elk, and moose. The Railroad Gulch site was also on the deer and elk winter range. This site occupied a midslope position 30 m above an intermittent stream, where the plant community consisted of bitterbrush and spotted knapweed. The High Rye site was 1500 m higher in elevation than the other MHWMA sites and appeared to receive the greatest snowpack. The plant community on the High Rye site was typical of the bitterbrush–rough fescue (*Festuca scabrella* Torrey ex Hook.) habitat type (Mueggler and Stewart 1980) with those species currently dominant. Guenther (1989) found the least amount of big game use at this location among the 4 MHWMA sites. The MHWMA study sites received insignificant levels of livestock grazing.

#### Sampling and Analysis

Leaves and leaders (current-year stem growth minus leaves) were collected at each study site from 10 randomly selected plants for crude protein analysis on each of the sampling dates. The same plants were sampled to determine leaf-to-leader ratios. Material was collected the 1st week of August prior to or at seed set in 1990 and 1991. This was estimated to be the period of minimum soluble carbohydrate content for bitterbrush plants (Menke and Trlica 1981). Material was also collected on 12 February 1991, when mule deer were concentrated on these sites. Plant material was oven-dried at 60°C for 48 h and weight of dry matter determined. Leaves were separated from leaders and weighed separately to determine leaf-to-leader ratios on a percent dry matter basis. Leaves and leaders were then ground to approximately 1 mm diameter in a grinder (Janke & Kunkel kg. type A10). Kjeldahl (nitrogen) analyses were used to arrive at crude protein contents. Winter crude protein values were calculated with a weighted average of winter leaf and leader protein levels. This allowed comparison with other studies (Dietz et al. 1962, Welch et al. 1983).

Soil samples were obtained at a depth of 15 cm below the surface from a soil pit in each study plot. Because soils at most sites contained a large rock fraction, it was necessary to sample at the relatively shallow depth of 15 cm to standardize sampling. The Montana State University Soil Test Laboratory performed organic matter determinations and total Kjeldahl nitrogen analyses on all non-MHWMA samples. Texture was determined by both the hydrometer and Bouyucous mechanical analysis methods. Soil pH was determined in 1 part soil to 2 parts water extractions. Topographic information was also recorded at each site. Aspect was determined by taking a compass bearing from the major slope. Slope was measured with a clinometer. Elevation was determined from USGS topographic maps. The information from MHWMA sites was derived from Guenther (1989).

A one-way ANOVA, with site as the factor, was conducted for each sampling date and protein source combination (Snedecor and Cochran 1989). This was done with the knowledge that protein sources (leaves or leaders) contained very different levels of crude protein within each sampling date. Site was also the factor in an ANOVA for percent leafiness for the February 1991 sample. The least significant difference (LSD) method ( $P < 0.05$ ) protected by a prior  $F$ -test ( $P < 0.05$ ) was used for comparing treatment means (Snedecor and Cochran 1989).

## RESULTS AND DISCUSSION

Crude protein levels differed ( $P < 0.001$ ) among sites within each protein source and collection date combination (Fig. 1). Thus, we rejected the hypothesis that crude protein values are equal during August and February among local stands of bitterbrush. Crude protein in the leaves, when averaged over all sites, varied with a 13% to 10% decline from August 1990 to February 1991 and subsequent increase to 15% by August 1991. Crude protein in the leaders for these 3 dates was 7.1%, 6.5%, and 7.2%, respectively, when averaged over all sites. These crude protein levels generally agreed with previous reports for bitterbrush throughout its range (Dietz et al. 1962, Bayoumi and Smith 1976, Morton 1976, Tiedemann 1983, Welch et al. 1983).

Protein levels also differed ( $P < 0.001$ ) among the 3 collection dates (Fig. 1). When all sites were pooled, August leaf protein increased 11% between years ( $P < 0.05$ ) and February leaf protein decreased 21% from August levels ( $P < 0.001$ ). Leader crude protein did not vary significantly between years but was higher in August 1991 than during the previous February ( $P < 0.05$ ).

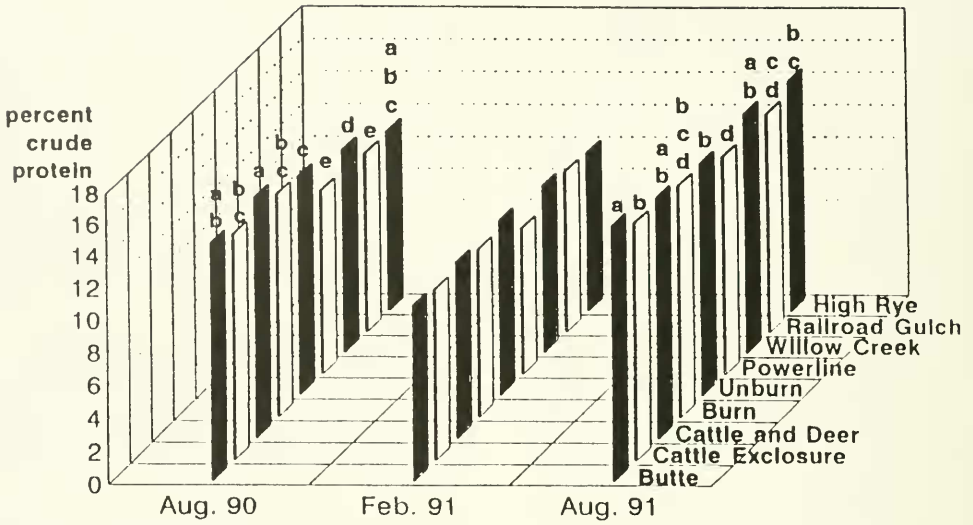
The unbrowsed Butte site rated highest in crude protein (Fig. 1) for 3 of the 6 measurements, although none was significantly higher than the next lower site. When the Butte site was compared to the aggregated crude protein levels of the other 8 sites, it was significantly ( $P < 0.05$ ) higher for both leaves and leaders in August 1990, but did not differ from browsed sites in February or August 1991. Thus, it does not appear that browsing affects crude protein levels.

Protein values for the 4 MHWMA sites were lower for August 1990 leaves ( $P < 0.07$ ) and leaders ( $P < 0.01$ ) than for other sites and collectively rated lowest for 4 of the 6 measurements. These site differences were not expected from Morton's (1976) work, but were supported by that of Giunta et al. (1978) and Welch et al. (1983).

Bitterbrush crude protein levels on the deer + cattle site were 1% higher ( $P < 0.05$ ) than on the adjacent cattle enclosure site for August 1990 leaves (Fig. 1). Other protein levels did not differ significantly between these 2 sites. Although a difference in use might thus seem to affect protein levels on these sites, the unbrowsed Butte site had higher protein levels than browsed sites in August 1990 ( $P < 0.05$ ) and no difference in February or August 1991.

Related to these site and possible population (Alderfer 1977) differences are soil differences. Soil samples from shrub interspaces (Table 2) contained 49% more soil nitrogen at the Butte site than at the burn and unburn sites and 78% more than at the cattle enclosure and deer + cattle sites. Bayoumi and Smith (1976) found a positive response of bitterbrush protein levels to fertilization with nitrogen, although Tiedemann (1983) found slightly negative to no response to fertilization. However, most desert shrubs accumulate nutrients under their canopies, and the surrounding interspaces have low nutrient content (Garcia-Moya and McKell 1970, Tiedemann and Klemmedson 1973), conditions that we did not sample.

### Leaves



### Leaders

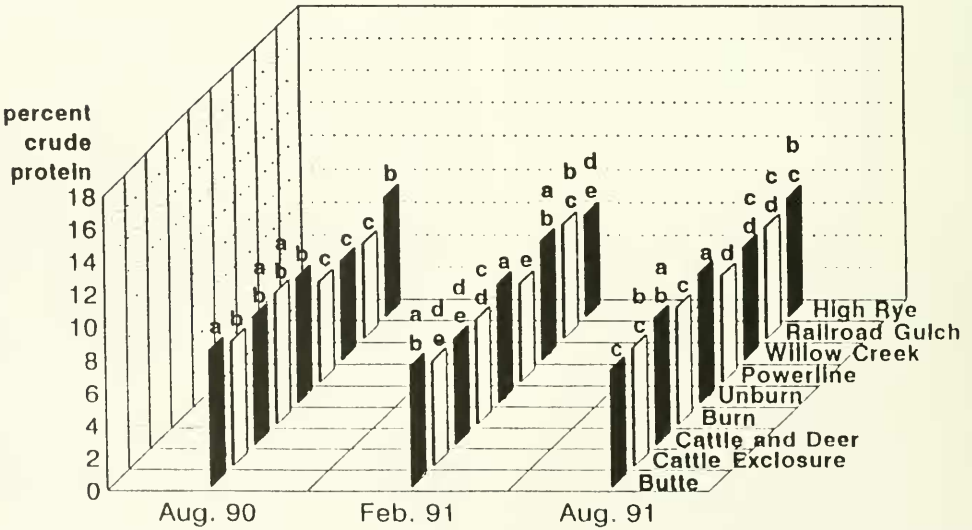


Fig. 1. Average percent crude protein in bitterbrush leaves and leaders found in August 1990, February 1991, and August 1991. Protein values within each protein source and collection date with similar lowercase letters are not significantly different (LSD,  $P > 0.05$ ). Insufficient leaf material was available for statistical analysis in February 1991.

TABLE 2. Soil characteristics for study areas, including pH, organic matter (OM), total Kjeldahl nitrogen (N), percent sand, silt, and clay, and textural class. Soil nitrogen was sampled at only 5 sites. Data from the last 4 sites were obtained from Guenther (1989).

Site	pH	OM (%)	N (%)	Sand (%)	Silt (%)	Clay (%)	Textural class
Butte	5.6	2.6	0.11	63	24	13	sandy loam
Cattle enclosure	5.7	1.0	0.06	80	12	8	loamy sand
Cattle + deer	5.7	1.0	0.06	80	12	8	loamy sand
Burn	6.3	1.1	0.07	67	23	10	sandy loam
Unburn	6.3	1.1	0.07	67	23	10	sandy loam
Powerline	5.8	1.4	—	65	15	20	sandy loam
Willow Creek	5.2	3.6	—	65	18	17	sandy loam
Railroad Gulch	5.7	1.0	—	72	18	10	sandy loam
High Rye	6.7	2.8	—	69	15	16	sandy loam

Protein levels at our study sites were therefore not necessarily related to soil nitrogen levels.

Although most leaves had fallen by February, all sites contained plants that had retained some leaves at that time. Bitterbrush phenology seems to vary more by season and climate than by ecotype (Shaw and Monsen 1983). Most leaves are deciduous, dropping in response to moisture stress in late summer or fall (Shaw and Monsen 1983), but some small leaves overwinter on some populations (Alderfer 1977). Dietz et al. (1962) alluded to the high protein level of leaves in winter but did not quantify those levels. Welch et al. (1983) reported that winter leafiness (presumably, weight of leaves compared with weight of stems) of plants from Idaho, Colorado, Utah, and California ranged from 5.9% to 15.5%, while combined leaf and leader crude protein ranged from 5.9% to 7.9%. These ranges are similar to values found for these Montana sites: leafiness (percent weight of leaves per weight of stems) of 1.5% to 15.8% and combined crude protein of 6.1% to 7.6% (Table 3). Because so few leaves were present in February (Table 3), crude protein in total foliage increased by only 0.3% over twigs alone for all sites.

Although we concluded that leaves contain significantly more crude protein than leaders on our study sites, leaf scarcity during winter in our region prevents total (leaf and leader) crude protein from meeting deer requirements (Welch et al. 1983). The February crude protein levels for total foliage averaged 6.8% across sites, which were below the estimated necessary threshold of 8.9% for wintering deer (Welch et al. 1983). However, September through November protein levels might have been higher, as many plants retained leaves through that period.

Guenther (1989) reported that deer pellets from the MHWMA sites contained large amounts of Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) and Oregon grape (*Berberis repens* Lindl.). Protein values for small winter samples of Oregon grape and juniper from the Willow Creek site were 8.4% and 6.9%, respectively. These values are below those reported by Welch et al. (1983) and, like bitterbrush, are also below what they considered to be the necessary threshold of 8.9% crude protein for wintering deer. Hamlin and Mackie (1989) suggested that mule deer have more need for high-quality forage in the fall, while building energy reserves, than in the winter. Bitterbrush in southwestern Montana may supply this needed level of nutrients in the fall, as we observed delayed leaf-fall on wind-protected bitterbrush plants in late November 1990, but we did not sample plants at that time.

Restoration efforts for ungulate winter ranges capable of maintaining bitterbrush may benefit through consideration of our results. We have found that bitterbrush populations of even a localized ecotype, such as we studied, should not be expected to attain the same levels of crude protein over different environmental conditions that will vary between sites. Revegetation of bitterbrush ranges will involve consideration for obtaining the best possible plant materials. Our evidence indicates that plant characteristics, other than protein content, should likely be of primary concern as protein can be expected to vary by site conditions regardless of plant material. However, it appears that consideration should be made of bitterbrush genotypes that maintain a high percentage of leaves into the winter. These genotypes may provide a higher level of crude protein that is desirable for wintering ungulates.

TABLE 3. Winter crude protein content (percent) of bitterbrush leaves and leaders combined and percent leafiness (percent weight of leaves per weight of stems) for study sites sampled February 1991. Column entries with similar letters are not significantly different (LSD,  $P < 0.05$ ).

Site	Crude protein (%)	Leafiness (%)
Butte	7.6 <sup>a</sup>	13.6 <sup>ab</sup>
Cattle enclosure	6.4 <sup>cd</sup>	6.5 <sup>d</sup>
Cattle + deer	6.6 <sup>e</sup>	9.9 <sup>e</sup>
Burn	6.7 <sup>bc</sup>	9.6 <sup>cd</sup>
Unburn	7.6 <sup>a</sup>	10.5 <sup>bc</sup>
Powerline	6.1 <sup>d</sup>	8.5 <sup>cd</sup>
Willow Creek	7.1 <sup>ab</sup>	8.1 <sup>cd</sup>
Railroad Gulch	7.2 <sup>a</sup>	15.8 <sup>a</sup>
High Rye	6.1 <sup>d</sup>	1.5 <sup>e</sup>

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